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Adaptation to Environment

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THE BASIC SCIENCE EDUCATION SERIES

ADAPTATION TO ENVIRONMENT

By

BERTHA MORRIS PARKER
LABORATORY SCHOOL, UNIVERSITY OF CHICAGO

Checked for Scientific Accuracy by
ORLIN D. FRANK, Teacher Emeritus,
LABORATORY SCHOOL, UNIVERSITY OF CHICAGO

Junior High

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Adaptation to Environment

The Menhaden

THE menhaden, you can see from the picture, is a fish. Since it is not often eaten, you may never have heard of it, but it is very common. Huge schools of menhaden are found along our Atlantic coast. In one of these schools the fish are crowded so close together that a fishing crew with a single "set" of their net may catch a quarter of a million.

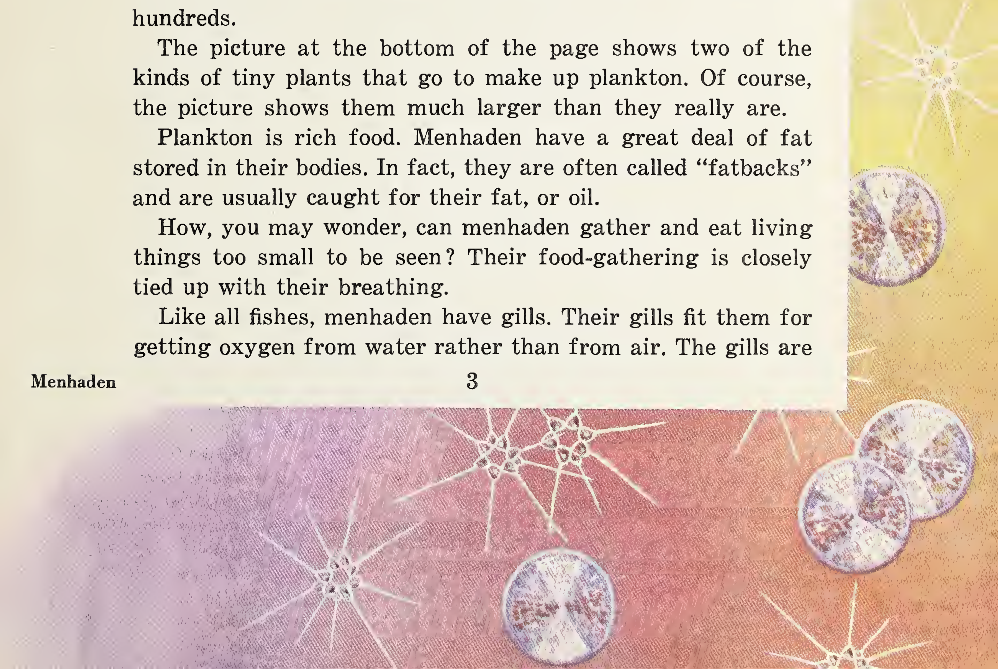
The abundance of the food they eat has a great deal to do with the enormous numbers of menhaden. They feed entirely on the *plankton* of the sea. "Plankton" is the name given to the very, very tiny plants and animals that float about at the surface of bodies of water. Most of these tiny living things are too small to be seen without a microscope. In parts of the sea they are so abundant that a single drop of water may contain hundreds.

The picture at the bottom of the page shows two of the kinds of tiny plants that go to make up plankton. Of course, the picture shows them much larger than they really are.

Plankton is rich food. Menhaden have a great deal of fat stored in their bodies. In fact, they are often called "fatbacks" and are usually caught for their fat, or oil.

How, you may wonder, can menhaden gather and eat living things too small to be seen? Their food-gathering is closely tied up with their breathing.

Like all fishes, menhaden have gills. Their gills fit them for getting oxygen from water rather than from air. The gills are



Angel Fish

fringes of thin membrane. Each thread in the fringes contains tiny blood vessels. To breathe, a fish takes water into its mouth and forces it past the gills and out through the openings at the sides of its throat. As the water passes the gills, some of the oxygen dissolved in it goes into the fish's blood.

On a menhaden's gills there are tiny projections called gill rakers. The gill rakers strain out the plankton from the water the fish takes in as it breathes.

The menhaden stays near the surface of the sea. The fat in its body helps keep it from sinking. Besides, like most fishes of the surface, it has a swim bladder. The swim bladder is full of air. A fish with a swim bladder works very much like a submarine. To go deeper, it takes a little air out of its swim bladder. To rise higher, it increases the amount of air there.

The menhaden has fins, just as all fishes do. It pushes its way through the water by curving its body first one way and then the other and by moving its tail and tail fin. Its other fins help it balance and guide itself.

Notice how different in shape the menhaden and the angel fish are. Both kinds of fish are streamlined, but the body of the angel fish is much shorter and deeper. Angel fish live in regions of coral reefs, where it is helpful to be able to stop quickly. Because of their shape, their bodies act as brakes if they are bent sideways. Menhaden, living as they do in the open sea, do not need to do much sudden stopping. Their bodies are fitted for fast swimming ahead.

The menhaden follows the usual fish plan of having scales and of being lighter colored below than above. The scales over-

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lap one another like the shingles on the roof of a house. They are fastened at their front edges only. Without interfering with fast swimming, they make a good protective covering. The coloring of the menhaden is protective, too. It helps hide the fish from its enemies. To birds above, the menhaden is the color of the water. To its fish enemies below, it is light like the sky.

You have seen a number of ways in which the menhaden is fitted for living where it does. Along a large part of our Atlantic coast, however, the water becomes too cold for it in winter. It escapes the cold by traveling out from shore in the fall to warmer water. In the spring it comes back again to the better plankton pastures near shore. This habit of traveling, or *migrating*, plays an important part in making the menhaden a very successful fish.

The Barn Swallow

Have you ever seen a barn swallow walking about in the park or in your back yard? The answer is sure to be "No." This bird, like all its swallow relatives, is a true creature of the air. It spends much of its time on the wing. The insects it eats it catches merely by flying fast with mouth open.

A barn swallow can fly much faster than a menhaden can swim. And no wonder! Both are streamlined, but it is much easier to push one's way through air than through water. On the other hand, the swallow must work much harder to keep from falling than the menhaden has to. As you already know, the menhaden can float in the water. A swallow cannot float in air. To keep from falling, it must keep moving, just as an airplane must.

Nest of Barn Swallow

Barn Swallow

Although a barn swallow cannot float, it does have a very light body. It weighs less than a mouse or a frog or a lizard that is the same size. One reason why a barn swallow weighs very little is that many of its bones, like bird bones in general, are hollow and are filled with air. Besides, the barn swallow, in common with other birds, has little sacs of air among the organs of its body. They act like tiny hot-air balloons.

The barn swallow breathes with lungs, just as we do. Lungs help fit it for a life in the air. The hollow spaces inside a bird's bones are connected with its lungs. So are the tiny air sacs you were told about.

Having strong wings is one of the most important ways in which the barn swallow is fitted for life in the air. A flying fish can soar through the air for a little way. A flying squirrel can glide down from one branch to another. But only creatures with true wings can really fly. With its wings the barn swallow beats against the air and moves itself forward as well as keeps itself from falling.

Feathers are excellent for wings: they are light, tough, and strong. Besides, feathers make an excellent protection for the bird's body. Birds are warm-blooded animals just as we are. Their feathers help keep them warm. Their feathers are also a good protection from rain. They shed rain because they are a little oily and because the parts of each feather and the feathers themselves are very cleverly fitted together.

The barn swallow's bill is short and broad at the base. This kind of bill lets a bird open its mouth wide. Being able to do so is a big help in catching insects in the air.

Insect food is hard to find during the cold winter months. The barn swallow, however, has no serious winter food problem because it migrates southward in the fall. Many swallows go as far south as northern Argentina. By migrating, the swallows not only find food, but they also escape the cold of our winters. They get more sunlight, too, than if they stayed in one place. In the spring they travel back to the north to build their nests of mud and straw and to raise their young.

The Arctic Fox

Far northern regions like the one shown in the picture below are not very hospitable places. But there are animals that can live even in such regions. The polar bear is one of them. Another is the arctic fox, the little "snowdog" of the north.

This fox is found in the open, treeless lands beyond our northern forests. Some arctic foxes live far enough north to have weeks of continuous night in the winter.

Arctic foxes live in burrows in snow or under rocks. Their thick fur helps protect them from the cold. An arctic fox has fur even on the soles of its feet. This fur not only helps protect the fox's feet from the cold but also keeps the fox from slipping as it travels over the ice.

Arctic Fox

As you might guess from the picture, the arctic fox is a meat-eater. In the summer it eats chiefly ptarmigans and other birds of the north, and bird eggs. In the winter it eats arctic hares, mice, and lemmings. It also follows the polar bear over the ice and eats the remains of seals the polar bear catches from the sea. The fox's well-known cunning is a help in catching animals. Its sharp teeth are good for tearing the flesh from the animals' bones.

The color of the arctic fox helps it survive in the far north. The foxes that live farthest north are white the year round. Those that do not live so far north are gray or brown during the summer but white during the long winter.

It is easy to see why it is a help for the fox to match its surroundings. Its color helps protect it from its enemies—the polar bear, the arctic wolf, and the snowy owl—by keeping them from seeing it easily. Moreover, its color helps hide the fox from the animals it catches for food. The fox can come close to its prey without being seen.

When food is plentiful, the fox may store some of it. For example, it often hides some of the lemmings it catches. Cracks in rocks serve as the fox's pantry. Having a store of food is important in a region where food is as scarce as it is in the far north.

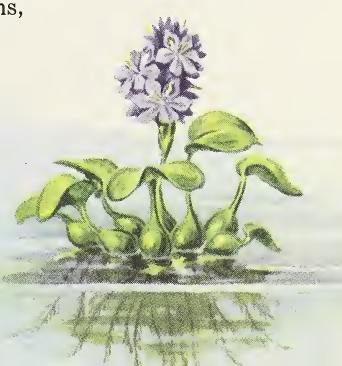
The Water Hyacinth

To some people in our country the water hyacinth is a pretty little plant worth buying to plant in goldfish ponds. To others it is a great nuisance, to be killed out wherever possible. Whether you think of this plant as a friend or an enemy depends on the part of the country in which you live. It is a nuisance in the south; in the north it is sold by plant nurseries.

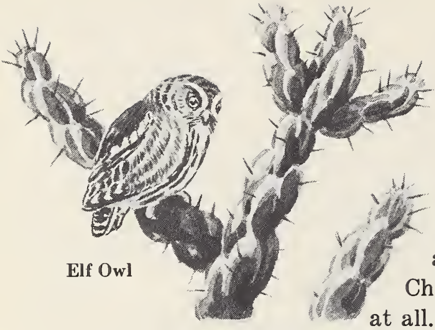
Like the Russian thistle, the tumbling mustard, and many of our other troublesome weeds, the water hyacinth is a plant immigrant. About sixty years ago it was brought from South America as a curiosity. Flower lovers bought specimens and set them out in garden pools. The plant could not stand the cold winters of our north, but in the south it escaped from the pools and spread rapidly. It soon became unpopular because it was fast clogging up streams and canals.

Of course, it could not have been so successful if it were not very well fitted for living in our southern waters. As you can see from the picture, it is a floating plant. Its leaves are mostly in the air, while its roots hang down in the water. No plant is better fitted for floating. The stalk of each leaf is swollen out into a "balloon" filled with air. Each leaf thus has its own life preserver that keeps it afloat even if it is torn away from the plant it grew on. If it takes some of the root with it, a new plant is almost sure to grow.

The fact that the water hyacinth floats so well explains why it spreads so fast. The current in a stream can carry it along easily. So can a stiff breeze. Their life preservers hold the leaves up high enough for the wind to catch them. When the plants find quiet water along the shore, they grow into floating masses of green leaves and lavendar blossoms, pretty to look at but far too much of a nuisance to be a welcome sight.



Water Hyacinth



Elf Owl

The Tree Cactus

Probably many people think of deserts as always very dry. Some deserts come close to being so. For example, in the arid region of northern Chile, ten years may go by without any rain at all. But showers are much more frequent in some deserts than they are in the one in Chile. Moreover, contrary to what you might expect, desert showers are not always light. Some are heavy enough to be called "cloudbursts." Such heavy showers occur once in a while in the desert regions of southern Arizona and northern Mexico. And it is in these regions that one of the best known of desert plants—the tree cactus—grows.

No plant is better fitted than the tree cactus for living in a place where the rainfall for the year is low but where there are occasional heavy showers. The cactus can "drink" enough during a good rain to last it a long time.

For one thing, it has roots that spread out in all directions not far below the surface of the ground. In a heavy rain much of the water runs off into streams instead of soaking down into the ground. If the cactus did not have roots close to the surface, very little of the water from the rain might reach them. As it is, they are almost sure to take in a great deal of water after a good shower.

Of course, it would not help for the roots to take in a great deal of water if there were no place to store it. From the picture on page 11 you can see that the stems of the cactus—its trunk and branches—are thick. They are pulpy inside and make excellent tanks for storing water.

The stems are not only big, but they can swell to take in all the water the roots can soak up. The picture shows that they are not smooth and round; instead, they are fluted—that is, they have deep grooves in them. Stems that are fluted can get larger and smaller more easily than smooth, round stems. They fold up a little like an accordion. After a heavy rain the trunk of a tree cactus may swell till it measures an inch more across than it did before. The trunk and branches together can hold enough water to keep the plant alive for a year or more even if there is no rain at all.

Probably you noticed at once that the tree cactus has no leaves. The stems are green and do the work which leaves do for most trees. Having no leaves helps the cactus save the water it takes in. Many, many gallons of water evaporate from the leaves of such a tree as a maple tree on a hot summer day. Because it has no leaves, a tree cactus does not have nearly so much surface from which the water can evaporate. Besides, the skin of the cactus stems is covered with wax. This wax helps hold the water in.

Many desert animals get a great deal of the water they need from the plants they eat. Juicy tree cacti would not have much of a chance to escape being eaten by desert animals if they were not covered with thorns. Their thorns, although they protect the plants rather well from being eaten, are not so formidable that they keep all animals away. The little elf owl, for example, builds its nest on the cactus branches. The tree cactus furnishes shelter for other desert animals, too.

Scientists believe that the earliest plants—the ancestors of the plants of today—all lived in water. Think how far the tree cactus with its many ways of fitting into desert conditions has come from those ancestors.

Tree Cactus

Mountain Sheep

Habitats

Every plant or animal lives naturally in some particular kind of place. Its natural place of living is called the *habitat* of the plant or animal.

The five plants and animals you have just read about have widely different habitats. And no one of them could live long in the habitat of any of the others. A menhaden and a barn swallow, for example, would both die within a very few minutes if they were to change places.

The pictures on this page and the next five pages show five other habitats. They are all very different, too. Not many of the plants and animals that live in one are likely to be found in any of the others.

Pictured on the inside covers are a number of the plants and animals that are fitted for living in ponds. Of the plants shown, some are wholly under water. Others float about on the surface of the water. Still others have their roots in the soil at the bottom of the pond but have their leaves and flowers well above the water. A fourth group of plants—a group that includes the cattail—grows at the edges of the pond. Most of the animals, too, are found in some special part of the pond. There are, you see, habitats within habitats.

Habitats may be different from one another in many ways. Some of the ways you have already seen.

One difference is in amount of moisture. The range in moisture is all the way from living under water to living in very dry air.

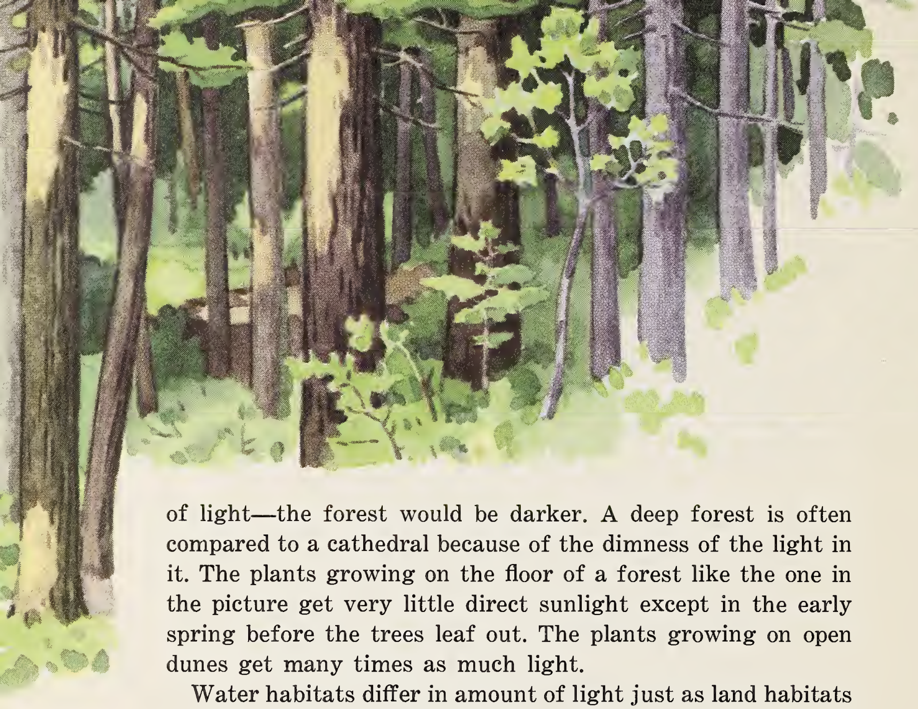
For land plants it is not only the moisture in the ground that counts but the moisture in the air, too. It would not be so important as it is for the tree cactus to be leafless if the air in the desert were not very dry.

Habitats may also differ greatly in temperature. The temperature of the regions where the arctic fox lives may be −60° F. or even lower. The temperature in the deserts where the tree cactus grows may be 130° F. or even higher.

Water habitats do not differ so greatly in temperature as land habitats do. The temperature of the ocean, for example, is never below 27° F. or above 88° F. Moreover, at any one place in the ocean the winter temperature is never more than 35 degrees lower than the summer temperature. In contrast, the lowest temperature of the winter in some land habitats may be more than 125 degrees below the highest temperature of the summer.

Suppose you were to walk, on a hot summer day, from the sand dunes in the picture on page 17 into the deep forest shown on page 14. What changes would you notice? You would probably be struck at once by the difference in temperature—the forest would be cooler. Another difference would be in amount

Prairie Gopher



of light—the forest would be darker. A deep forest is often compared to a cathedral because of the dimness of the light in it. The plants growing on the floor of a forest like the one in the picture get very little direct sunlight except in the early spring before the trees leaf out. The plants growing on open dunes get many times as much light.

Water habitats differ in amount of light just as land habitats do. When light shines on water, much of it is likely to be reflected from the surface. But the plants growing in the shallow water of a clear stream like the one shown on page 15 get a great deal of light. Plants in deep water, however, get very much less.

Some animals thrive in bright sunlight while others live only where it is dark. In the sunny deserts where the tree cactus grows you would find horned toads and little collared lizards. Bats are common in caves, where the light is dim. Moles and earthworms get almost no light at all.

We are used to having day and night in every twenty-four hours. In part of the region where the arctic fox lives, as you have already been told, there is a period of weeks when the sun is not above the horizon at all. It is easy to see that a plant or animal that is successful in the part of the world where we live might not be able to live in a region where there were long periods of darkness.

Pressure is something else which may be different in different habitats. On every square inch of your body the air is pushing with a force of about fifteen pounds. This means that on your whole body the air is pushing with a force of about fifteen tons. This force would crush you if the air and blood and water inside your body were not pushing out as hard as the air is pushing in the opposite direction. As it is, you usually do not notice the pressure of the air at all. You notice it only when you go to a place where the pressure is less or greater. The higher a place is above sea-level, the less is the pressure there. The pressure where the mountain sheep are found is several pounds less per square inch than at sea-level.

Plants and animals that live under water have to withstand the pressure of the water. The water pressure on the seashore animals shown in the picture on page 16 is not very great, but at a depth of a mile in the ocean the pressure is enormous. There the water pushes with a force of about a ton on every square inch of surface. No wonder deep-sea fishes die when they are pulled up to the surface quickly.

The air pressure high above sea-level is much less, you have seen, than the pressure at sea-level. Besides, the amount of oxygen in a given volume of air is much less. Oxygen is the part of the air that we must have. All living things need oxygen. At sea-level in a cubic yard of air there is about half a pound of oxygen. Eighteen thousand feet above sea-level there is only a fourth of a pound of oxygen in a cubic yard of air. But some

Brook Trout

animals can live on a scanty supply of oxygen. Toads and wolves have been found at more than 16,000 feet. And several kinds of birds have been seen flying at much higher levels. In India, geese, for example, have been seen flying at 29,000 feet—up where there is only about one-seventh of a pound of oxygen in a cubic yard of air.

As a rule, plants and animals that live under water use oxygen that is dissolved in the water. Curling waves on the surface of lakes and ponds and seas do a great deal toward trapping oxygen. In streams, rapids and waterfalls are a help.

Warm water cannot hold so much oxygen as cool water. You may have read of the great fishing banks of the North Atlantic. The abundance of fish in the cool waters there is explained partly by the greater supply of oxygen in those waters.

If you were to test for oxygen the water in the trout stream shown on page 15 and the water in the seashore habitat pictured on this page, you would probably find more in the trout stream. This would be partly because the ocean water contains more salt. Salt water cannot hold so much oxygen as fresh water of the same temperature.

Another way habitats differ is in the food to be found there. Menhaden would not get along well in a clear, swift-flowing trout stream partly because they would not find enough food. In the same way, mountain sheep, that eat nothing but plants, could not live in the region pictured on page 8.

Animals of the Seashore

Sand Dune

Green plants, if they can get the right materials from the air, water, or soil they are growing in, and if they have plenty of light, can make their own food. Animals must get their food from the plants and animals around them. So must plants that are not green. From the standpoint of food, then, it makes a great difference to some plants and to all animals what their neighbors are.

What its neighbors are may make a difference to a plant or animal in other ways. Some of its neighbors may be a help in other ways besides furnishing food. Some flowering plants, for example, cannot produce seeds unless there are insects to carry pollen from flower to flower. On the other hand, some of the neighbors of a plant or animal may be, in a sense, its enemies. The gopher can be thought of as the enemy of the prairie grasses it eats, and the barn swallow as the enemy of the insects it catches as it flies about. Clearly, in thinking of the habitat of any animal or plant, you should think of its neighbors as well as of moisture, temperature, light, oxygen, and pressure.

When a plant or animal is well fitted for living in the habitat where it is found, we say that it is well adapted to its environment, or surroundings. Each way in which it fits into its surroundings is called an adaptation to environment. You already know about some of the ways in which certain plants and animals are fitted for living where they do. The pages that follow will tell about other adaptations to environment.

Getting Water

Getting water is not a problem for the menhaden, the brook trout, and the water hyacinth. It is very much of a problem for the tree cactus and the plants of the sand dunes.

One way of meeting the problem of getting enough water where water is scarce is to be small. It goes without saying that a small plant or animal does not have to have so much water as a big one. Many plants that live where water is scarce are dwarfs. Mesquite is a tree in the moist river bottoms of the Southwest, but it is only a shrub in the desert. The three animals on this page are all desert animals, and none of them is very large. They need, moreover, very little water for their size. The kangaroo rat, in fact, gets all the water it needs from its food, and the jack rabbit gets most of its water in that way.

Another way of meeting the problem of water scarcity is for a plant or animal to have a good way of storing up the water it does take in. The camel is the best example of an animal that stores up water. As you have already found out, the tree cactus has stems that are really folding water tanks.

Slowing up evaporation is also a way of solving the problem. The tree cactus, you remember, cuts down evaporation by having no leaves and by having a covering of wax. Many other desert plants are leafless and have a wax covering. Many desert plants that do have leaves have thick, wax-covered leaves that serve as little storage tanks.

Jack Rabbit
Horned Toad
Kangaroo Rat

Thick skins help keep many animals from losing too much water by evaporation. If a jellyfish, with no thick skin to protect it, is washed up on shore, it soon loses most of the water in its body and dies.

Even in regions of much moisture, some groups of plants have to have special ways of getting enough water. The *epiphytes* make up one of these groups. Their name means "upon a plant." An epiphyte is a plant that grows perched up away from the ground on another plant. The plant in the picture on this page is an epiphyte. Its stiff leaves form a "rain barrel." These leaves have a special way of taking in the water that is caught in the "rain barrel."

Mistletoe grows on trees in moist regions, but it has a very different way of getting the water it needs. A mistletoe plant sends little rootlike branches into the tree on which it is growing. Then it "steals" some of the water the tree has taken in through its roots.

It is hard to imagine that a plant growing in water could have any trouble getting great amounts, but many plants in bogs are not able to take in very much water. For some reason that no one knows, plants that grow in bogs have very poor systems of roots. Perhaps the bog water is somewhat poisonous; perhaps it has too little oxygen in it. At any rate, more than a few of the plants that grow in bogs are able to get along with so little water that they can also grow on dry, rocky cliffs. As you can guess, many bog plants are small and have thick skins.

Most of the animals we know best drink water. Some, as you know, get all they need in the food they eat. It simply soaks in through the skins of many water animals, and even some land animals can get the water they need in this way. A toad, for example, may sit in a puddle of water to get a drink.

There are still other ways in which living things solve the problem of getting enough water. The whole story of how plants and animals are fitted for getting the water they need is a very long one.

An Epiphyte

Getting Oxygen

There are five big groups of animals with backbones: fishes, amphibians, reptiles, birds, and mammals. Of these five groups, the reptiles, birds, and mammals are chiefly land animals. They are fitted for taking the oxygen they need from the air. They all have lungs, just as we do. Fishes, of course, are all water animals. They are fitted for getting oxygen from air that is dissolved in water. They all have gills. The lungfishes have lungs as well. Amphibians live in water when they are young. They breathe with gills. Later most of them develop lungs, become air-breathers, and spend much of the time out of water.

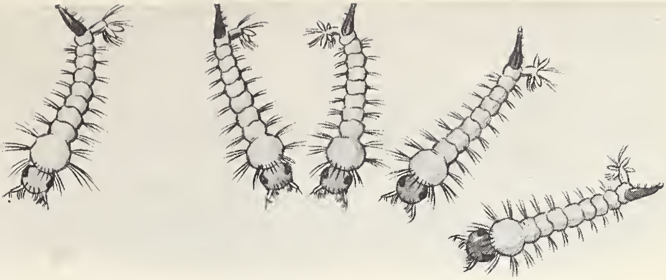
Some animals without backbones do not have special organs for breathing. These animals all live either in water or in moist places. Oxygen travels through their moist skin to the cells where it is needed. The earthworm is one of the animals that breathe through their skin.

Many animals without backbones breathe with gills. Lobsters, crayfish, and starfish are among them. These, you are sure to know, live in water.

Many insects spend their early lives under water. Some of them breathe with gills when they are under water. Full-grown insects are all air-breathers. Most of them get air through *spiracles*, tiny openings in the sides of their bodies. The air goes into branching air tubes.

All spiders are air-breathers. Some have air tubes. Others breathe with book lungs.

Water Spider
Dolphin
Climbing Perch



Young Mosquitoes

Book lungs are sacs filled with thin flaps of skin arranged side by side like the pages of a book. Some spiders have both air tubes and book lungs.

Getting oxygen is usually not much of a problem for water animals with gills or for land animals with lungs or air tubes. It is much more of a problem for air-breathers that live in water and for underwater breathers that have to be out of water at times. The pictures on these two pages show four animals that have special ways of getting the oxygen they need.

The water spider has to breathe air. It stores air under the water in a bell-shaped web. To fill the bell, the spider goes up to the surface of the water and catches air among the hairs of its body. Then it dives down, goes under the "bell," and scrapes the bubbles of air off its body with its legs.

The dolphin is a mammal. It breathes with lungs as all mammals do, and must, therefore, come to the surface to get air. Its lungs, however, can hold a large supply of air so that it does not have to breathe in and out fifteen or twenty times a minute as we do.

During periods of dry weather, streams and ponds in which there are fish may dry up. Lungfishes breathe with their lungs in such periods. The climbing perch, which has no lungs, solves the problem in a different way. It travels overland to some other stream or pond. During its trip it is able to breathe, because it holds water around its gills by closing its gill covers.

Mosquitoes live under water when they are young, but they are air-breathers even then. They get air through air tubes. A young mosquito hangs head down in the water with the opening of its air tube just at the surface of the water.

Water Lily

Plants have to have oxygen, just as animals do. This statement may surprise you, because you may have heard that green plants take in carbon dioxide and throw away oxygen. They do when they are making sugar for food. In the sugar-making, oxygen is formed as a waste product. More is formed than the plant needs, and some is thrown away. But sugar-making goes on only in light. When it is dark, green plants take in oxygen and throw away carbon dioxide. Most plants that are not green take in oxygen and throw away carbon dioxide all the time.

Plants that live under water simply take in the oxygen or carbon dioxide through their outer covering. As a rule, underwater leaves are narrow and thin. Oxygen and carbon dioxide can easily reach all the cells of the leaves.

Most land plants take in oxygen through pores in the skin of their leaves. These pores are called *stomata*. They lead into air spaces.

The water lily pictured above has large, thick leaves that float on the water. Most leaves have their stomata on the under side. The stomata do not so easily become clogged with rain water or with dirt when they are in this position. But water lily leaves have their stomata on the upper surface. Having their openings for air in this position is, then, another of the many special adaptations found among living things for getting the oxygen they need.

Getting Food

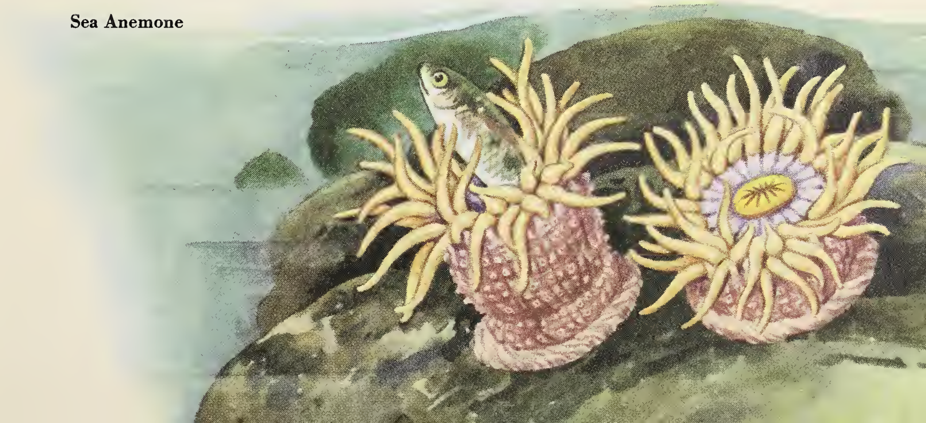
The menhaden, the barn swallow, and the arctic fox are well fitted, you have already found out, for getting food from their surroundings. The gill rakers of the menhaden, the short, broad bill of the barn swallow, and the sharp teeth of the arctic fox, as well as its color, are all adaptations for food-getting. Among living things there are almost countless similar adaptations.

So far as their ways of getting food are concerned, animals can be divided into two classes—those that hunt for their food and those that wait for food to come to them. The picture below shows one of the kinds of animals that wait for food to come to them.

Sea anemones swim about when they are very young. But soon they fasten themselves to rocks or shells in shallow water along the seashore. They eat other animals. Around their mouths they have many feelers. When a small animal comes near, a sea anemone shoots out from its feelers tiny poison darts on the ends of threads. If the animal is hit by a dart, the sea anemone's feelers fold around it and bring it to the anemone's mouth. One of the anemones in the picture, you can see, has just caught a small fish.

On the rock in the lower right-hand corner of the picture on page 16 there are some barnacles. Adult barnacles also wait for food to come to them. Barnacles have feathery legs that come out when the shells are open at the top. These legs "kick" tiny animals into the mouths of the barnacles.

Sea Anemone



The way the sea anemone and barnacle get food would not be at all good in some water habitats. But along the seashore the tides carry much food within the reach of these animals.

The starfish, another of the seashore animals in the picture on page 16, has a quite different method of getting food. On the under side of its arms it has many tube feet, with tiny suckers at the ends. It goes hunting for food along the ocean floor. When a starfish finds an oyster or a scallop, it fastens the tube feet of one or more of its arms to each half of the animal's shell. Then it pulls and pulls until the shell opens.

As you can see from the middle picture on page 25, the bill of a hummingbird is much longer and thinner than the bill of a barn swallow. It is fitted for reaching far into flowers and getting the nectar and tiny insects found there.

There are many other types of bird's bills, too. Each is fitted for getting food in a different kind of way. The woodpeckers have strong, sharp bills with which they can dig holes in wood to get insects. The cardinals and the sparrows have short, strong bills that are fitted for cracking seeds to eat. The pelican has a "fish basket" for a lower bill. The woodcock can feel around in the ground for food, because its bill is flexible at the end. The turkey buzzard has a bill that is suited for tearing the flesh from the bones of dead animals. And so it goes.

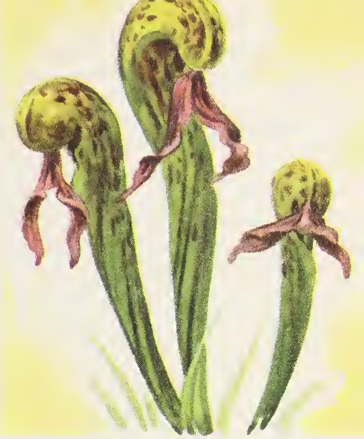
The long neck of a giraffe lets it eat leaves from high in trees. The great anteater's long snout and very long, sticky tongue let it catch ants and termites by the thousands. The squirrel's sharp teeth enable it to gnaw through the thick shells of nuts. The mole has big front feet and long, sharp claws that let it dig tunnels underground to find earthworms and insects to eat. The sphinx moth drinks nectar from flowers through a long tube. Spiders have spinnerets with which they can make webs that serve as insect traps. These are only a few of the many, many adaptations found among animals for food-getting.

Parasol Mushroom

You have already found out that green plants make food for themselves if they have plenty of light and can get the right materials. But the soil or water in which they are growing may not have a plentiful supply of the right materials. Pitcher plants grow in swamps where nitrogen, one of the materials plants must get from soil or water, is likely to be scarce. They are fitted for living in swamps partly because they have a way of getting extra nitrogen. They trap insects and get nitrogen from the bodies of the insects, just as we get nitrogen from the meat we eat.

The leaves of the pitcher plant shown on this page are excellent insect traps. The banners hanging down from the mouths of the pitchers attract insects. Once inside a pitcher, an insect cannot easily find its way out. Thin places in the "hood" are like windows. The insect keeps flying toward these instead of toward the real opening. At last the insect becomes tired and falls into the water at the bottom of the pitcher. Then it is ready to be digested by the leaf.

There are many plants—the mushrooms among them—that cannot make food for themselves because they are not green. The parasol mushroom pictured on the opposite page lives on dead wood or some other dead plant material. The part of the mushroom plant that is underground is made of long threads that find their way into the food material and absorb it through their thin walls. It is clear, then, that among plants as among animals there are to be found adaptations for food-getting.



California Pitcher Plant
Hummingbird
Sphinx Moth

Getting Warmth

Warmth is very important to all living things. As you probably know, all living things are made of cells. The living material in these cells—the "basic stuff of life"—is *protoplasm.* Protoplasm cannot stand either extremely high temperatures or extremely low ones. It coagulates, just as white-of-egg does, if it gets too hot, and it freezes if it becomes too cold.

Protoplasm varies somewhat, so that the temperature at which it coagulates is not always the same. Neither is the temperature at which it freezes. There is danger of coagulating whenever the temperature reaches 158° F. There is danger of freezing whenever the temperature goes as low as 23° F.

The freezing temperature probably surprises you. There are, as you know, many animals and plants that stand temperatures much lower than that.

There are only two ways living things can get the warmth they must have. One is to get it from their surroundings. Plants and cold-blooded animals depend almost entirely on this way. Warm-blooded animals may get warmth from their surroundings, but they also get it from their food.

The arctic fox, polar bear, arctic hare, lemming, and ptarmigan are, you have found, animals that can live successfully in very cold regions. They all belong to one or the other of the two great groups of warm-blooded animals—birds and mammals. Even when the temperature of their surroundings is –60° F., the body temperature of these animals is about 100° F.

Skunk

Young Seal

The heat which makes birds and mammals warm-blooded comes from the oxidation, or slow burning, of their food. Warm-blooded animals eat a great deal more food for their size than do cold-blooded animals. All animals must have food to furnish them with energy. Warm-blooded animals need extra food to keep their bodies warm.

But in very cold regions it would probably be impossible for any warm-blooded animals to eat enough to keep warm if they did not have ways of keeping the heat of their bodies from escaping. Fur and feathers are both excellent for shutting heat in. They are both very poor conductors of heat—that is, heat cannot travel through them at all easily. Tiny pockets of air help make fur and feathers poor conductors.

Fat is also a great help in keeping animals of cold regions warm. Underneath the skin of a baby seal, for example, there is a thick layer of fat. Fat is a poor conductor of heat. It is excellent fuel, too, that can be "burned" in the animal's body whenever it is needed.

Oxidation of food also goes on in cold-blooded animals and in plants. But it goes on so very slowly that it seldom makes the animals and plants any warmer than their surroundings. In the winter honeybees do form into ball-shaped clusters inside their hives and make themselves warmer than their surroundings by burning food as they carry on a kind of dance. But the plants and most of the cold-blooded animals that survive temperatures below 23° F. do so, not because they have any way of getting warm, but because they have some way of keeping from freezing when they become very cold.

Deep-Sea Shrimps

Getting Light

Green plants have to have light. If they cannot get light, they cannot make food for themselves, and without food, of course, they cannot live.

Sunlight cannot shine very far down through water. No sunlight at all reaches depths below 3,300 feet. For this reason there are no green plants deep in the oceans. In fact, there are few that are more than 300 feet below the surface.

Even on land it is not always easy for green plants to get the light they need. In a dense forest, for example, a never-ending struggle for sunlight goes on.

Since light is very important to green plants, you might expect that some of them would be specially fitted for getting the light they need. And they are. The branches of a tree serve to spread the tree's leaves out in the sunlight. Try to imagine all the leaves of a big maple tree crowded in to the trunk. How few of them would get enough sunlight!

In tropical forests some trees grow very tall and slender so that their leaves are up above the leaves of the shorter trees. In these forests there are many climbing plants, too. Some climb by twisting their stems around other plants. Some cling to other plants by tendrils. Some even have flowers that are little sucking discs like the discs on the toes of tree toads. "Plant acrobats" these plants have been called that climb high to get sunlight.

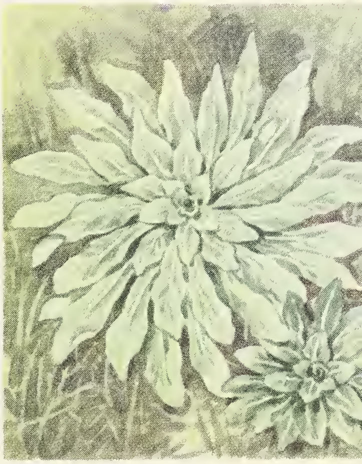
Notice the leaf arrangement of the plants in the middle picture on this page. Many plants besides the evening primrose have their leaves arranged in rosettes like these. Although the leaves in a rosette are close to the ground and some are on top of others, all of them get sunlight. They are able to because of their different lengths.

Animals do not have to have light in order to make food for themselves—only green plants can make their own food—but light plays an important part in helping many animals find their food. For without light they could not see.

The mole is almost never aboveground. It is fitted for living without light. No wonder its eyes are so small that it is hard to tell that it has any at all.

The whirligig beetle, on the other hand, has two pairs of eyes. As it whirls about on the surface of a pond, it sees through the water with one pair of eyes. With the other pair it sees through the air.

As you already have been told, no green plants grow deep in the oceans. But animals have been brought up from more than three miles below the surface. The animals of the deep sea have to get their food from the other animals around them or from dead plants and animals that sink down from above. There is no sunlight to show them their food. Some deep-sea animals, however, give off light of their own, just as the shrimps on page 28 are doing. This light is believed to attract prey as well as to let the animals see their food. It is doubtless a real help in a world of no sunlight.



Mole
Evening Primrose
Whirligig Beetle

Ways of Moving

Most plants live their whole lives in one place. They do very little moving about. But seeds travel. So do spores, which serve as seeds for mushrooms and many other plants that have no seeds. Pollen, the colored "dust" which plays an important part in the forming of seeds, travels, too.

Different plants have different ways of sending their seeds traveling. Some send them traveling by air, some by water, and some by land. No seed plant is well adapted to its environment unless its way of scattering seeds is a suitable one for that environment.

Dandelions grow on lawns and along roadsides. The wind can reach them easily. Their seeds are fitted for traveling by air. Each seed has fastened to it a tiny parachute of down. Many kinds of seeds have parachutes. Many others have wings which serve the same purpose.

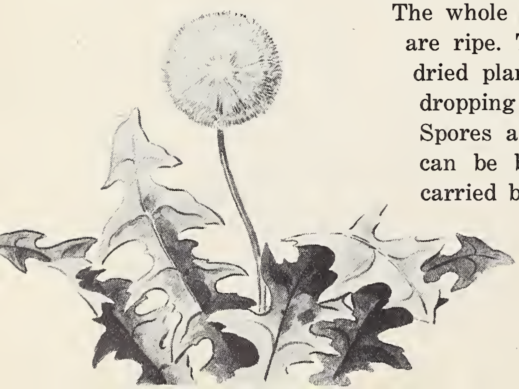
The American lotus, a water plant, sends its seeds traveling in holders that are good boats. Coconuts, the seeds of coconut palms, can float long distances on water.

Cockleburs have a way of sending their seeds traveling that is especially good in a region where there are many furry animals. Their "packages" of seeds have stickers which catch in the fur of animals. Many other plants have this same way of getting their seeds scattered.

Hundreds of kinds of plants have bright-colored, pulpy fruits that help them get their seeds scattered. Birds and other animals eat the fruits and scatter the seeds.

Tumbleweeds have an excellent way of scattering seeds in a region where there are wide open spaces. The whole plant dries up when its seeds are ripe. The wind then breaks off the dried plant and sends it rolling along, dropping seeds as it goes.

Spores are very tiny and light. They can be blown about by the wind or carried by water.



Penguin

Most pollen is carried by either wind or insects. Many plants have their flowers at the tops of tall stalks. The wind can get at them easily there. Ever so many flowers have sweet nectar that invites insects. As an insect gets nectar, it gathers pollen on its body. It then carries the pollen to another flower. Some flowering plants have very special ways of insuring that insects will carry their pollen.

Although some animals live their whole life in one place, moving about is the rule rather than the exception. And there are many ways in which animals can move about. Perhaps the easiest is simply to float on the surface of water as jellyfish do, but of course that way of moving about is impossible on land. It is, moreover, by no means the best way of moving about in water, for a jellyfish has no way of guiding itself.

When we think of the way water animals travel, we are sure to think of swimming. It is by far the commonest way of traveling among the larger water animals. But not all swimming animals swim in the same way. Fishes, as you know, all have fins which help them. Whales, dolphins, and sea turtles have flippers which serve as paddles. Water birds, as a rule, swim with their webbed feet, but penguins use their wings, which have become flippers. Beavers and otters swim with their legs.

The animals on the ocean floor have many different ways of moving about. The sideways walk of the crabs, the slow movement of the starfish on their tube feet, and the hitching along of the clams are well known to visitors at the seashore.

Flying and gliding are the two chief ways of traveling by air. For going long distances by air, flying is the only way.

Among the many ways of moving on land are crawling, digging, scampering, walking, running, hopping, leaping, climbing, and swinging from tree to tree. Some of these are suitable for one habitat, and some for another.

By simply looking at an animal you can often tell what its chief way of moving is. The strong hind legs of a kangaroo, for example, tell that this animal travels by leaping. In the same way, the front feet of the mole and the long arms of the monkey tell how these animals travel.

If their environment slowly changes, animals sometimes change so that they are better fitted for moving about in the changed surroundings. The horse is a good illustration.

Fifty million years ago the first horses we know about lived in swampy, wooded country. Their feet were good for walking on soft, wet ground; there were four toes on each front foot and three on each hind foot. But the swampy woodlands little by little gave way to firm grassland. And, generation by generation, horses changed, too. Now a horse has on each foot only one toe that reaches the ground, and the nail on this toe has become a thick hoof. Today's horses are as well fitted for running across grassy plains as the first horses were for running in and out among the trees of a swampy forest.

Means of Protection

Being able to move fast is the best way many animals have of protecting themselves from their enemies. Some animals—the swallow for one—have no other way.

The arctic fox and menhaden, you remember, are protected by their color. Many other animals have protective coloring. Some animals, like the arctic foxes just north of the northern forests, change color with the seasons. Some animals change color more often. The common tree toad is one of those that do. It changes from gray to green, for example, if it moves from the trunk of a tree to a green leaf.

The walking-stick insect is protected by its resemblance to a twig. The dead-leaf butterfly escapes being seen by its enemies because it looks like a dried leaf. This means of protection is called protective resemblance.

Many animals have armor of some kind. The shells of the clams, oysters, scallops, and other shellfish are good armor. So are the hard coverings of the beetles, the shells of the turtles, the tough hide of the elephant and hippopotamus, and the plates of the armadillo.

Some animals have good weapons. The spines of the porcupine, the tusks of the wild boar, the sword of the swordfish, and the sharp claws of the tiger are examples. The sea anemone, as you

found out, has poison darts. A number of other animals protect themselves by poison. A soldier termite shoots out a sticky liquid at its enemies through a sort of squirt gun in its head. Some animals protect themselves by giving out a bad odor. The skunk, as you know, protects itself in this way.

Animals may have habits which help protect them from their enemies. The opossum, for instance, plays dead. The hog-nosed snake protects itself in the same way. Many animals escape their enemies by doing their hunting at night.

Plants cannot run away from their enemies, but they have some of the same means of protection which animals have. Many have spines. You can see from the middle picture on this page that spines can be formidable weapons. The skunk cabbage and a number of other plants protect themselves with a bad odor. Some plants have a bad taste, which serves the same purpose.

Plants and animals need protection from other things besides their enemies. Bad weather is one of the most important. Some living things are protected from bad weather by thick coverings. The young plant in a black walnut seed has a very thick cover which is so hard that we need a hammer to break it open. In the fall a cecropia caterpillar wraps itself up in a cocoon made of many layers of silk. You have seen that fur, feathers, and fat are good protection against cold.

Many plants and animals store up food in preparation for cold weather. Bulbs, for example, contain much stored food. So do

Porcupine
Cactus
Toad

thick roots such as beets and carrots. Chipmunks are among the animals that store food. As much as half a pint of wheat, a quart of hazelnuts, two quarts of buckwheat, and half a peck of acorns has been found in a chipmunk's storehouse.

It helps many trees keep from freezing to death in the winter to drop their leaves in the autumn. We do not know the whole story of how some plants keep from freezing in very low temperatures. We do know that in the leaves of evergreen trees there is much more sugar in the cell sap during the winter than there is during the summer. The sugar doubtless keeps the sap from freezing. Probably a change much like the one in evergreen leaves takes place in the cells of other living things.

Woodchucks, toads, frogs, and many other animals *hibernate* during the winter. They choose protected places for their winter sleep. Frogs, for example, bury themselves in the mud at the bottom of ponds. This mud, although it may become very cold, is almost sure to stay above the freezing point for protoplasm.

Migration is another way of avoiding the dangers of cold weather. You have found that the menhaden and the barn swallow migrate. So do many other animals. The middle picture on this page shows one of the best known of our migrating birds. No one is sure how migration came about, but it certainly serves to let animals live in more favorable temperatures than they could have if they stayed in one place the year around.

Chipmunk
Canada Goose
Cecropia Cocoon

See for Yourself

1. Choose any plant or animal not pictured in this book. Find as many ways as you can in which the plant or animal is fitted for living where it does.

2. Set up several terrariums illustrating different habitats. One might be, for example, a swamp habitat in which you had a pitcher plant and some of the other plants that eat insects. Another might be a desert habitat with cactus plants and a small desert lizard or two. Still another might be a woods habitat with small ferns, very tiny trees, a toad, etc.

3. Set up a fresh-water aquarium.

4. Set up a marine aquarium.

5. Make a collection of seeds and sort them according to their ways of traveling.

6. Make a study of the legs and feet of birds. Find how the birds' legs and feet are related to the environments in which the birds live.

7. Plan and set up some experiments to show the effects on plants of varying the amount of light, the temperature, the moisture in the soil, and the moisture in the air.

8. Insects are very successful. They have been called the rivals of people partly because they can live in so many different kinds of places. List ten habitats and find at least one kind of insect that lives in each habitat.

9. Dig up a dandelion plant. Find all the ways you can in which the dandelion is fitted for living where it does.

10. Make a collection of pictures that show protective coloring.

11. Find as many ways as you can in which the loon differs from the barn swallow. Which of these appear to be adaptations to the different environment in which the loon lives?

12. The flounder is a fish which spends its life on the ocean floor. Find as many ways as you can in which the flounder differs from the menhaden. Which of these appear to be adaptations to the different environment in which the flounder lives?

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